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ABSTRACT

We ask whether banks use interest rate swaps to hedge the interest rate risk of their assets, primarily loans and securities. To this end, we use regulatory data on individual swap positions for the largest 250 U.S. banks. We find that the average bank has a large notional amount of $434 billion. But after accounting for the significant extent to which swap positions offset each other, the average bank has essentially no net interest rate risk from swaps: a 100-basis-point increase in rates increases the value of its swaps by 0.1% of equity. We find variation across banks, with some bank swap positions decreasing and some increasing with rates, indicating that banks use swaps to move interest rate risk across banks. We conclude that swap positions are not economically significant in hedging the overall interest rate risk of bank assets.

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I. Introduction

Banks are in the business of borrowing short and lending long, which exposes them to interest rate risk. In particular, on the lending side, the values of fixed-rate loans and investments in fixed-rate securities declines when market interest rates rise.

Market interest rates increased from January 2022 to March 2023 as central banks tightened monetary policy to combat inflation. In the United States, the Federal Reserve Bank increased the market short-term rate, i.e., the Fed Funds rate, from close to 0% in early January 2022 to around 4.5% in February 2023. Furthermore, over the same period, the long-term or more specifically 10-year rate– which can be conceptualized as depending on the expected sequence of short-term rates plus a term premium– increased from around 1.5% to 4%. These large increases in market interest rates significantly lowered the value of bank loans and securities. Drechsler, Savov and Schnabl (2023a), conducting a simple back-of-the-envelope calculation, estimate that the U.S. banking sector lost around $700 billion on security investments and a total of $1.75 trillion on both securities and loans.

These large losses raise the question of whether banks use interest rate swaps ("swaps") to hedge their holdings of securities and loans. Because swap values are themselves subject to interest rate risk, swaps can and are commonly used to manage interest rate risk exposures, not only in the banking sector but across the financial system. According to the Commodity Futures Trading Commission, the notional amount outstanding of swaps at the end of 2021 was $215 trillion.[2] There is, of course, a cost to hedging securities and loans with swaps: whatever term premium is earned from holding securities and loans is likely given up by hedging with swaps. But this observation does not diminish the importance of our primary question, namely, whether or not banks use swaps to hedge the value of their assets against changes in rates.

It is difficult for researchers and the public to answer this question because granular data as to bank swap positions are not publicly available. In theory, the reported market values of swaps positions over time, as interest rates change, can be used to back-out the interest rate exposure of those positions. In practice, however, these efforts are complicated by accounting complexities and by the fact that swap positions typically change between the reporting dates of their market values.

By contrast, this paper can precisely measure the interest rate exposure of bank swap positions because we have regulatory (non-public) contract-level data on those positions. Our

[2] Baker, Mixon and Orlov (2022).

analysis focuses on the positions of the largest 250 U.S. commercial banks, which amount to more than 8 million contracts and constitute nearly the entirety of swap positions of the U.S. banking sector. In this way, our data allow us to measure and evaluate the interest rate exposure of swaps both at the level of individual banks and for the banking sector in aggregate.

We present bank swap positions using two common metrics. The first, notional amount, measures the total dollar amount (or foreign currency amount converted to dollars) that is referenced by all relevant swap positions. For example, the notional amount of a fixed-for-floating interest rate swap is the dollar amount used to calculate the interest rate payments required by the contract. Notional amounts are straightforward to compute and widely reported, although as discussed later, they cannot be interpreted as measuring the interest rate exposure of swap positions.

The notional amount of the swap positions of the largest 250 U.S. banks is \$94.7 trillion, which is large and equal to about seven times the total assets of the U.S. banking system. The swap positions are concentrated among larger banks, especially among swap dealers. Swap dealers are banks that are registered with the CFTC to make markets in swaps. The notional amount of their swap positions is \$93.7 trillion or 11 times their assets.

The second metric we use to present bank swap positions is DV01 (the dollar value of an '01), which is the change in value of a swap position due to a one-basis-point decline in a suitably-defined interest rate. Computing this direct measure of risk is impossible without detailed information about the relevant swap positions that is not publicly available. DV01 is used to measure interest rate risk not only by banks, but widely across the financial industry, and not only for swaps, but for all assets with values that are sensitive to interest rates, including a bank's securities and loans.

Despite the large notional amounts just described, we find that the swap position of the average U.S. bank has essentially zero exposure to interest rates. The stark difference between the two metrics arises mostly because the notional amount of a portfolio of swaps adds the notional amounts of individual positions, even though typically some positions increase in value as rates decline while other positions decrease in value as rates decline. Put another way, the interest rate risks of swap positions within a bank typically offset each other.[3] In any case, the average DV01 across the largest U.S. banks is only \$3 million and the median DV01 is only \$10,000. To put these values into perspective, compare banks' swap DV01– their interest rate risk exposure in swaps– to bank equity– their capacity to absorb risk. The mean ratio of DV01 to bank equity is only -0.001% and the median ratio

[3]Another reason for the discrepancy is that there is a very large notional amount of short-term swaps, which have particularly low exposure to interest rates. See Baker et al. (2021).

is less than 0.001%. Put another way, a 100 basis-point increase in interest rates changes average bank equity by less than 0.1%.

The DV01 of bank swap positions is economically small when compared with the interest rate risk of bank assets. Drechsler, Savov and Schnabl (2021) report that the average U.S. bank has an asset duration of around 3.9 years (i.e., a 100-basis-point increase in interest rates reduces asset value by 3.9%). Given bank leverage of about 10 to 1, this decline in bank assets reduces bank equity by 39%. Hence, bank swap positions do not have significant interest rate risk relative to that of bank assets. Equivalently, the average bank does not rely on swaps to hedge the interest risk of its securities and loans.

This conclusion holds both for the large banks that are and that are not swap dealers. The average swap dealer has an average DV01 of $52 million, or about 0.01% of bank equity, which means that a 100 basis-point-increase in rates reduces bank equity by 1.0%. For the average non-swap-dealer, DV01 is less than $10,000 and, in absolute magnitude, about 0.002% of bank equity. Again, these estimates are economically small when compared to the interest rate risk of bank assets.

We gain additional insight from the variation of DV01 across the 250 largest banks. DV01 varies from −$1 million at the 5^{th} percentile to $3 million at the 95^{th} percentile, and the ratio of DV01 to bank equity varies from -0.031% to 0.025%. The distribution of the ratio of DV01 to equity is close to symmetric, implying that losses from interest rate changes at one bank are offset by gains at another bank. Furthermore, for some banks the negative DV01 of swap positions offsets some of the DV01 of assets, while for other banks the positive DV01 of swap positions adds to the DV01 of assets. But, as discussed above, these offsetting or additive contributions to DV01 are limited relative to the DV01 of assets. Hence, the swap positions of banks do not seem to be motivated by the interest rate risk of bank assets.

We also analyze the interest rate risk of swap positions for the banking system as a whole, proxied by that of the largest 250 banks. Aggregate DV01 is $585 million, or 0.038% of aggregate bank equity. Alternatively, a 100-basis-point increase in rates would lower the value of aggregate bank equity by 3.8%. The suggestion, again, is that swap positions in the banking industry are not primarily motivated by the interest risk of bank assets.[4]

In summary, while the notional amount of bank swap positions is very large, the interest rate risk of those positions for the average bank is close to zero, both for swap dealers and non-swap-dealers. Furthermore, while the aggregate interest rate risk of swap positions of the banking sector is small, for some banks swaps somewhat offset the risk of assets and for

[4]Note that data from the Commodity Futures Trading Commission for Q1 2023 show that swap-dealer banks have positive DV01, non-swap-dealer banks have negative DV01, and, when combined, these positions effectively cancel and result in an essentially zero exposure across the sector. https://www.cftc.gov/sites/default/files/2023-01/ENNs_IRS_2022Q3_ada.pdf.

others swaps somewhat add to the risk of assets. We conclude that bank swap positions are not economically significant in hedging the interest rate risk of bank assets.

We emphasize that these findings do not imply that individual banks or the banking system overall are unhedged to interest rate risk. Drechsler, Savov and Schnabl (2021) shows that banks hedge long-term asset holdings with their deposit franchise. While the deposit franchise is difficult to analyze, as its valuation depends on assumptions about depositor behavior, Drechsler, Savov and Schnabl (2023b) provide back-of-the-envelope estimates. They find that from January 2022 to March 2023, as interest rates increased, the value of the banking sector's deposit franchise increased by around $1.7 trillion, which is the same order of magnitude as the losses on bank assets over that period. They emphasize that this valuation is uncertain and depends on behavioral assumptions regarding depositor behavior.

Our paper contributes to the literature on the interest rate risk of bank swap positions. Brewer III, Minton and Moser (2000) show that banks using interest rate derivatives experience greater growth in their books of commercial and industrial loans. Purnanandam (2007) finds that banks using derivatives do not need to adjust either lending volumes or the gap between the maturities of assets and liabilities in response to tighter monetary policy. Gorton and Rosen (1995) devise a methodology to infer exposure from a combination of notional amounts, reported swap market values, and assumptions about the evolution of swap positions over time. Stulz (2004) analyzes the cost and benefits of derivatives such as interest rate swaps. Begenau, Piazzesi and Schneider (2015) estimate the interest rate exposure of bank swap positions from changes in the market values of swap positions over time. Hoffmann et al. (2019) analyze the distribution of interest rate risk of European banks using regulatory data. Drechsler, Savov and Schnabl (2021) show that the deposit franchise functions like swap positions in hedging the interest rate risk of bank assets. Baker et al. (2021) study how swaps are used to tranfer interest rate risk from various sectors to others, including banks. Our paper is unique in the existing literature in studying this subject using regulatory data on individual swap positions throughout the U.S. banking system.

II. Literature

The academic literature explains several ways in which firms can increase value by hedging, that is, by reducing the volatility of cash flows or of profitability: reducing the likelihood of costly episodes of financial distress (Smith and Stulz (1985), Stulz (1996)); minimizing expected taxes, either directly, because the tax function is convex, or indirectly by increasing debt capacity, which, in turn, provides valuable tax shields (Smith and Stulz (1985), Stulz (1996), Leland (1998), Graham and Rogers (2002)); mitigating underinvestment, risk-shifting, and other agency problems (Campbell and Kracaw (1990), Stulz (1990), Bessembinder (1991)); avoiding the need for costly external financing of future investments (Froot, Scharfstein and Stein (1993)); and reducing the volatility of executive compensation (Stulz (1984), DeMarzo and Duffie (1995)).

Derivatives, by their nature, allow firms to adjust their risk profiles relatively easily. For example, a producer that makes bread from wheat can typically hedge the risk of higher wheat prices much more efficiently by buying wheat futures contracts than by borrowing money, purchasing wheat, and then storing that wheat until it is needed. On the other hand, and by the same logic, this bread producer can much more efficiently speculate on or increase risk exposure to wheat prices by buying or selling futures. The natural question, therefore, is whether, in practice, firms use derivatives to hedge or to speculate. The question takes on particular public policy importance in the context of banking where increased risk taking can have systemic implications. For a general discussion along these lines, see, for example, Stulz (2004).

In investigating whether derivatives are used for hedging or speculation, academic papers might be divided into three broad approaches. The first asks whether firms using derivatives are indeed exposed to risks that can be hedged with those derivatives and, in addition, whether firm using derivatives have characteristics that align with the theories of hedging described earlier. To cite a few papers in support of the hedging hypothesis, Géczy, Minton and Schrand (1997) show that firms with greater investment opportunities, tighter financial constraints, and significant exposure to foreign-exchange rates are more likely to use currency derivatives. Carter and Sinkey (1998) find that the use of interest rate derivatives by non-dealer banks is associated with larger gaps between the maturities of their assets and liabilities. Minton, Stulz and Williamson (2009) show that banks that are net buyers of protection through credit default swaps have relatively large loan books, low capital ratios, and high risk-weighted assets relative to assets. They also find, however, that relatively few banks use credit default swaps and, across those that do, the net amount of protection bought is very small relative to loan balances. Guay and Kothari (2003) also observe, in the context of nonfinancial firms, that the magnitudes of derivatives exposures are very small relative to the scale of operations and underlying exposures. They conclude from this order of magnitude discrepancy that derivatives use is consistent with hedging that is limited to particular business lines or to fine-tuning overall firm exposures, but is also consistent with speculation. Finally, Chernenko and Faulkender (2011) find evidence supportive of both hedging and speculation. With respect to hedging, high-investment nonfinancial firms with cash flows that rise with short-term rates use derivatives so that their overall structures of their liabilities float with rates as well. But derivative use and the overall structures of liabilities over time also depend on the levels of short-term vs. long-term interest rates, which is more indicative of speculation on the future evolution of rates.

The second research approach to investigating whether derivatives are used for hedging or speculation is to explore exactly how derivatives increase firm value. Brewer III, Minton and Moser (2000) show that banks using interest rate derivatives experience greater growth in their books of commercial and industrial loans. Purnanandam (2007) finds that banks using derivatives do not need to adjust either lending volumes or the gap between the maturities of assets and liabilities in response to tighter monetary policy. Campello et al. (2011) examine private credit agreements and conclude that firms using interest rate and foreign-exchange derivatives borrow at lower rates and are subject to fewer restrictive investment covenants. And Pérez-González and Yun (2013) show that the introduction of weather derivatives adds value to firms by making possible more aggressive financing and higher levels of investment. Some of our paper fits into this research approach by showing that banks use interest rate swaps to facilitate their lending businesses, or, more specifically, to help their customers hedge the risks of their borrowings through floating-rate loans.

The third research approach, which most closely resembles that of our paper, is to assess directly how the risk exposure of derivatives positions relates to the risk exposure of some indicator of firm value (e.g., stock returns, income, value of assets and liabilities). This approach has been particularly challenging until relatively recently, however, because details on derivatives positions were neither publicly reported nor privately reported to regulators. Hirtle (1997), for example, uses the notional amounts of interest rate derivatives to show that increases in these notional amounts– particularly for dealers– marginally increase the interest rate sensitivities of bank holding company stocks over half of the time period studied, which result is not consistent with derivatives as hedges. Gorton and Rosen (1995) avoid relying on notional amounts as a metric of derivatives interest rate exposure, as do many papers in this area, by devising a methodology to infer bank derivatives exposures from a combination of notional amounts, limited available information on derivatives market values, and strategic assumptions about the evolution of derivatives positions over time. Using this methodology, they present evidence of hedging in that large banks, which are the dominant users of interest rate derivatives, have positive 12-month maturity gaps– meaning that balance sheet items increase in value when rates increase– against derivatives positions that decline in value when rates increase. Their analysis also reveals that the interest rate sensitivity of net income offsets much of the interest rate sensitivity of derivatives positions.

A working paper by Begenau, Piazzesi and Schneider (2015) also develops a methodology to estimate the interest rates exposures of bank derivatives positions from available data, in particular, from changes in the market values of derivatives over time, the reporting of which had significantly improved since Gorton and Rosen (1995). In any case, combining these estimates with estimates of the interest rate exposures of on-balance-sheet positions (e.g., securities and loans), produces results that are similar to ours in many ways. In particular, both papers find that bank derivatives portfolios typically fall in value as rates increase, as do bank securities and loans portfolios. Begenau, Piazzesi and Schneider (2015) conclude from this finding, however, that banks typically use derivatives to increase their exposure to interest rates, that is, banks are not using derivatives to hedge. We come to a very different conclusion. Following Drechsler, Savov and Schnabl (2021), we recognize that bank deposit franchises have significant duration.

III. Measuring Interest Rate Risk from Swaps

In this section, we discuss the measurement of interest rate risk for banks, which results from their exposure to interest rate derivatives, assets, and liabilities. Our primary focus is on interest rate risk stemming from interest rate swaps. To begin, we provide an overview of interest rate swaps and explain how they generate interest rate risk exposure. Subsequently, we describe how we measure a bank's interest rate risk using CFTC data on interest rate swaps. Finally, we describe our methodology for measuring the interest rate risk associated with a bank's assets and liabilities.

A. Primer on Interest Rate Swaps

The most prevalent form of swaps is a fixed-for-floating swap, in which one party agrees to receive a fixed rate and to pay a floating rate on some notional amount for a fixed term, while the other party agrees to pay that fixed rate and to receive that floating rate on the same notional amount for the same term. To illustrate with a simple example, suppose that Bank A and Bank B enter into an agreement in which Bank A will receive annual interest payments from Bank B at a rate of 2% per year for 10 years on a notional amount of $100 million and, in exchange, Bank A will pay Bank B quarterly interest payments on future realizations of 3-month LIBOR for 10 years on the same $100 million.[5] In other words, Bank A and Bank B agree to exchange interest payments such that Bank A receives payments based on a fixed rate and makes payments based on a floating rate, while Bank B receives payments based on a floating rate and makes payments based on a fixed rate.

The fixed rate of 2% on the swap in the example is called the swap rate and is determined by market conditions at the time of the trade. More generally, the swap rate is set such that the two counterparties are willing to enter into the swap without either paying the other an upfront amount, or, equivalently, such that the value of the swap at initiation is zero. The $100 million is called a notional amount rather than a principal amount or face amount because it is used only to calculate contractual interest rate payments. The notional amount is not paid or received by either counterparty through the swap.

While the value of a swap is zero at initiation, its value changes over time as interest rate change. In the example, suppose that just after the initiation of the swap the market 10-year swap rate suddenly declined from 2% to 1%. From the perspective of Bank A, the value of the swap– commonly referred to as its "net present value" or NPV– would then increase from $0 to about $9.5 million: it locked in receiving 2% over 10 years in a market in which the fair rate is now only 1%. By the same logic, the NPV of the swap to Bank B is approximately negative $9.5 million. If, on the other hand, the market 10-year market swap rate suddenly rose from 2% to 3%, then the NPV of the swap would be about negative $8.5 million to Bank A and positive $8.5 million to Bank B. Note that the positive NPV of one counterparty to a swap is typically well protected from a default of the other counterparty the collateral or margin posted by that counterparty.[6]

A fixed-for-floating swap essentially resembles a levered purchase of a default-free bond financed by short-term borrowing. In the context of the example, Bank A pays nothing at the initiation of the swap; receives 2% on $100 million over 10 years; and pays the floating interest rate on the same amount over the same time period. But these cash flows are the same as those from purchasing a 10-year bond financed fully by short-term borrowing over time at prevailing short-term rates. Hence, the fixed receiver in a fixed-for-floating swap (Bank A in the example) may be said to be "long" the swap, just as the purchaser of a bond is long the bond, while the fixed payer (Bank B in the example) may be said to be "short" the

[5] The floating-rate index of swaps has transitioned away from LIBOR to SOFR (Secured Overnight Financing Rate). For details on this transition see, for example, Tuckman and Serrat (2022), pp. 289-295. In any case, because the sample period of this paper falls firmly in the LIBOR regime, the text describes swaps in terms of LIBOR.

[6] For more detail on the pricing of swaps and collateral protection, see Tuckman and Serrat (2022), Chapters 2 and 13.

swap, just as a short seller of a bond is short the bond.[7]

With this background, the discussion can turn to metrics of "exposure" for swaps. For a single swap, notional amount is directly related to the size of the interest payments exchanged, but is a very coarse measure of interest rate risk: the NPV of a 1-year fixed-for-floating swap with a notional amount of $100 million is much less exposed to interest rate risk than a 30-year fixed-for-floating swap with the same $100 million notional amount. And the notional amount of a single fixed-for-floating swap is a very poor measure of counterparty default risk: the contract never calls for the exchange of notional amounts and, as just mentioned, collateral arrangement typically protect positive NPVs from counterparty defaults.

For a portfolio of swaps, "long notional amount" is defined as the sum of the notional amounts of all individual swaps that increase in value when rates fall; "short notional amount" is defined as the sum of the notional amounts of all individual swaps that decrease in value when rates fall; and "notional amount" is defined as the sum of long and short notional amounts. Long and short notional amounts suffer as measures of interest rate risk and counterparty risk along the same lines as does the notional amount of an individual swap. Total notional amount is an even worse metric as it adds long and short exposures, while the risks of the long and short sides typically offset each other. Net notional amount, defined as the difference between the long and short notional amounts, corrects this problem, and is a metric that is comparable to the notional amount of an individual swap.

Another common metric of exposure for swaps is the market value of an individual or of a portfolio of swaps, which is defined as the sum of the NPVs of the individual swaps in that portfolio. Market value is not a measure of the interest rate risk of a swap, as it simply reflects the change in NPV from the initiation of the swap to the present. Put another way, the interest rate risk of a swap can be high even if its market value of zero. For this reason, we do not consider the market value as informative about a swap's interest rate risk.[8]

Our preferred measure of the interest rate risk of a swap or of a portfolio of swaps is DV01, which is defined as the change in the NPV of the swap or portfolio of swaps in response to a one-basis-point decline in interest rates. DV01 is one of the most commonly-used metrics of interest rate risk for trading and internal risk management across the financial industry, by

[7]While this terminology is convenient here, note that practitioners almost always speak in terms of "receiving fixed" and "paying fixed" rather than "long" and "short," respectively. Note too that, historically, the convention was actually the reverse of that suggested in the text, namely, to refer to receiving fixed as "short" and paying fixed as "long," as in Gorton and Rosen (1995).

[8]Market value is also not a good measure of the counterparty risk of a swap. First, market value adds NPVs across counterparties, that is, across claims that do not offset in the event of a default. Second, market value does not incorporate posted collateral, which protects NPV in the event of a counterparty default.

banks along with other financial institutions, and for swaps along with bonds and structured products.[9]

Our discussion so far focused on fixed-for-floating swaps, which is the most prevalent form of an interest rate swap, but there are other forms of swaps, most notably overnight index swaps (OIS), swaptions, forward rate agreements (FRA), and caps and floors. OIS are very similar to interest rate swaps, but fixed-rate payments are exchanged for floating payments that are based on compounded interest of an overnight rate, like the federal funds rate, rather than on a term rate, like LIBOR. FRAs require a single payment that depends on the difference between a fixed rate and a short-term rate, which means that they are effectively single-period IRS for forward settlement. Caps, floors, and swaptions are various forms of options on rates or IRS. According to data from the Commodity Futures Trading Commission, the proportions (as measured by risk outstanding) of these products are: IRS, 87%; OIS, 6%; swaptions, 5%; FRAs, 2%; and caps or floors, less than 1%.[10] There are also interest rate derivatives that are not swaps, most notably futures contracts on short-term rates and on longer-term bonds. However, the outstanding quantity of interest rate risk in swaps is between 6 and 9 times as large as that of these futures contracts.[11]

B. Measuring interest rate risk of interest rate swaps

We obtain data on swap contracts from the Commodity Futures Trading Commission (CFTC). Historically, the CFTC regulated futures markets, but the Dodd-Frank Act expanded its mandate to include "swap" markets, which in this legal context refers very broadly to over-the-counter derivatives markets.[12] In accordance with this expanded mandate, the CFTC subsequently promulgated various regulations including the requirement that "U.S.-reporting entities" report swap trades and open positions to swap data repositories (SDRs), which, in turn, make these data available to the CFTC. "U.S.-reporting entities" include U.S. entities, U.S. subsidiaries of foreign entities, and swap dealers registered with the CFTC, who from all other perspectives are foreign entities. Not surprisingly, U.S. commercial banks, the focus of this study, generally qualify as U.S.-reporting entities and their

[9] For a more detailed exposition, see Tuckman and Serrat (2022), Chapter 4.

[10] Baker et al. (2021), Table 2.

[11] Compare, for example, Baker et al. (2021) with Baker, Haynes and Tuckman (2019).

[12] The Dodd-Frank Act actually divides over-the-counter derivatives into "swaps" and "security-based swaps." "Swaps" are derivatives on general market variables and indexes, like IRS, and are regulated by the CFTC, while "security-based swaps" are derivatives on particular entities, like credit default swaps on individual corporations or total return swaps on individual stocks, and are regulated by the Securities and Exchange Commission.

swap trades are included in this regulatory data set.

Motivated by the findings in Section IV that swap positions are concentrated in the largest banks, we focus on the 250 largest FDIC-insured U.S. commercial banks, by assets, as reported by the Federal Reserve Board as of June 2018.[13] The assets of these top 250 banks, by the way, range from about $3 billion to over $2 trillion. We obtain CFTC data on the swap positions of these banks from the third quarter of 2017 through the fourth quarter of 2019. We drop banks that are subsidiaries of other banks in the list along with those that were acquired or participated in a merger of equals over the sample period. This leaves a sample of 218 banks that we use throughout the paper.

CFTC data include the contractual features of every swap position at each bank in the sample. From these data we compute, for each bank and for the all banks, long notional amount, short notional amount, and net notional amount. The DV01 of each swap is also available from the CFTC, calculated by the CFTC's Office of the Chief Economist as part of its ongoing public reporting of Entity-Netted Notionals (ENNs), a risk-adjusted measure of the size of various derivatives markets.[14] ENNs, and therefore these DV01s, are computed quarterly as of a date in the middle of the last month of each quarter so as to avoid any quarter-end effects that might temporarily distort notional amounts outstanding. The methodology used by the CFTC to compute DV01s follows standard industry conventions and takes as input industry-generated curves of fixed-for-floating swap rates across tenors.[15]

IV. The Rise of Interest Rate Derivative Swaps

Interest rate derivative positions in the U.S. banking sector have grown enormously since the birth of the market in the 1980s. Panel A of Table 1 gives summary statistics computed from publicly available call reports on banks' usage of interest rate derivatives in five-year intervals from 1985 to 2020 and for the year 2022. While 1995 and later data include interest rate derivatives other than swaps, e.g., exchange-traded derivatives, the vast majority of positions are swaps, as discussed further below. In any case, the notional amount of interest rate derivatives in 1985 was $186 billion, which was roughly the size of bank equity at the

[13] https://www.federalreserve.gov/releases/lbr/20180630/default.htm

[14] See Baker et al. (2021).

[15] When computing the DV01 of a swap, it is most common to start with a term structure of fixed-for-floating swap rates, value the swap, reduce the term structure of rates across all terms by one basis point, recompute the value of the swap, and take the change in the value of the swap as its DV01.

time. By 2010, notional value had increased more than 1,000-fold to $193.4 trillion, which was 16.3 times bank assets. Notional amounts declined after 2010 because the regulatory mandate to clear swaps facilitated "compression," that is, the reduction of notional amounts without altering risk profiles. In 2022, the total notional amount was $139.6 trillion, which was 6.4 times bank assets.[16]

Interest rate derivative notional amounts are highly concentrated in the largest banks. Panel A of Table 1 shows that the percentage of all commercial banks with interest rate derivative positions increased from 2% to 23% from 1985 to 2022. Hence, while the percentage of banks having exposure to these derivatives gradually increased, that percentage remains limited. Or, put another way, the median bank has no exposure to these derivatives. Furthermore, Panel B shows that the participation rates of the largest 250 banks, by asset size, are much more significant, growing from 53% to 90%, and that their notional amounts dominate the market. Even though the largest 250 banks constitute less than 5% of banks, their notional amounts account for more than 99.9% of all notional amount over the entire history. Not surprisingly then, notional amount relative to assets or to equity is greater for the largest banks than for banking sector as a whole, peaking at about 18.7 times assets in 2010 and remaining at a relatively high multiple of 7.1 times assets in 2022.

Panel C of Table 1 focuses on banks registered with the CFTC as swap dealers, a designation created by the Dodd-Frank Act that essentially identifies market makers. There were 12 registered swap dealers from 2010 to 2018, and 11 after 2018. The data show that these relatively few dealers account for about 99% of interest rate derivative notional amounts, $191 trillion of the total $193 trillion in 2010 and $136 trillion of the total $139 trillion in 2022. Notional amount relative to assets for this group is larger than for the largest 250 banks at 28.9 times assets in 2010 and 11.9 times assets in 2022.

Table 2, also using data from publicly available call reports, provides additional insight into the concentration of notional amounts across banks by listing the largest 20 banks by assets as of December 2022. The eight largest banks include seven swap dealers. These seven swap dealers stand out with large notional amounts ranging from $45.9 trillion to $537 billion. These notional amounts are also large multiples of assets, ranging from nearly 94.2 to 1.0. The remaining 12 banks on this top-20 list have significantly lower notional amounts. Four of them are swap dealers, but collectively they are smaller banks by assets

[16]Before the clearing mandate, swap contracts were bilateral, that is, between pairs of individual market participants. Since the mandate, the vast majority of swap notional amount is between individual market participants and a clearinghouse or central counterparty (CCP). This change in market structure enabled compression cycles in which the risks of all swaps between each market participant and a CCP are aggregated, netted, and then replaced by a smaller number of swaps that preserve each of these aggregated and netted risks.

and notional amounts. Their total notional amount ranges from $359 billion to $0 billion, or, as multiples of assets, from 1.0 to zero.

All in all, Tables 1 and 2 show that the notional amount of interest rate derivatives is highly concentrated in a small number of banks. Not only is almost all of the outstanding notional amount accounted for by the largest 250 banks, but notional amount is also concentrated in the very largest of these banks, particularly in swap dealers. Motivated by these findings, our empirical work focuses on the largest 250 banks and we pay special attention to swap dealers.

V. How exposed are banks to interest rate swaps?

A. Interest rate swap positions

Table 3 presents summary statistics on swap positions at the bank level and in aggregate for the banking sector. As discussed earlier, our data is quarterly from the third quarter of 2017 to the fourth quarter of 2019 and includes 218 of the largest U.S. banks. The total value of bank assets in our sample is $13.5 trillion (Column 1), which constitutes around 93% of total bank assets during the analysis period. The mean bank size is $62 billion and the median is $9 billion (Columns 2 and 4). Banks are primarily funded with core deposits, which constitute 66.1% of overall bank liabilities and around 74.9% for the average bank. On the asset side, loans account for 54.8% of aggregate assets and 69.3% for the average bank; securities account for 19.7% in aggregate and 17.7% for the average bank; and cash accounts for 9.7% in aggregate and 4.5% for the average bank.

The notional amount of swaps in the U.S. banking system is $94.7 trillion.[17] Notional value is about seven times as large as total assets in the U.S. banking system and about twice as large as the amount outstanding of U.S. debt securities. Most of the notional value is concentrated in the largest banks, as can be seen from the distribution of notional value across banks. As shown in Column 2 to 4, the mean notional value per bank is $434 billion, or 10.8% of bank asset value, which is much greater than the median notional value of $0.4 billion, or 3.91% of bank asset value. There is also large dispersion in terms of notional value relative to bank assets ranging from 60% at the 95^{th} percentile of the distribution to 0% at the 5^{th} percentile. Further along these lines, many smaller banks in the sample have no position in swaps. More specifically, in a given quarter, about 26% of banks have no

[17]This value is computed from data obtained from the CFTC, which does not include exchange-traded interest rate derivatives.

swaps position. Note that this is consistent with our finding in Section IV that many mid-sized banks and the vast majority of small banks– which are not included in our sample– have no position in swaps.

Table 3 also presents data indicating that banks use swaps to facilitate their business of making loans to customers. On average across banks, 80.4% of the swap notional amount in which banks receive fixed is with customers rather than other dealers. These swaps likely facilitate customers' transforming the floating-rate loans they take from banks into fixed-rate obligations: a customer paying a floating-rate on a bank loan combined with a swap with the bank in which the customer receives a floating rate and pays a fixed rate nets to a fixed-rate obligation. The significance of these swaps is similar in risk terms, as 82.1% of the DV01 of swaps in which banks receive fixed is with customers. The corresponding percentages for the banking system as a whole are much lower, at about 47% each, because the largest of the large banks are swap dealers for whom the lending business is much smaller relative to the market making business.[18]

Our data also include the fair market value of swaps. As discussed earlier, the market value of an interest rate swap is zero at initiation and changes as interest rate change. As shown in Column 1 of Table 3, the total market value of bank derivatives is $50 billion, or about 0.4% of bank asset values. Similar to notional value, the market value is concentrated among large banks. The mean market value is $232 million, which is a small fraction of bank asset value, and the median market value is close to zero. There is significant dispersion across banks with market value relative to bank asset value ranging from −0.122% at the 5^{th} percentile to 0.312% at the 95^{th} percentile. As discussed above, even though market value is commonly reported, it does not provide any information over and above our other measures of swap positions.

B. Interest rate risk of swap positions

Table 3 shows that the $94.7 trillion aggregate notional amount falls by a factor of 100 to $784 billion after netting. This illustrates, as discussed earlier, that notional amount without netting is effectively meaningless in terms of measuring interest rate risk. Netting long and short positions further reveals that most smaller banks have little net interest rate exposure. Across all banks, the mean net notional is $3.6 billion, while the median is nearly

[18] All of these percentages are computed using the positions of banks with strictly positive notional amounts.

zero. Also, net notional is concentrated in the largest banks.[19]

We now turn to our preferred measure of interest rate exposure, DV01, described earlier. Swap DV01 for the aggregate banking system is $585 million and, like notional and net notional amounts, is concentrated among large banks. The mean and median swap DV01 are $3 million and $10,000, respectively. And there is considerable dispersion across banks: the swap DV01 is $3 million at the 95^{th} percentile and −$1 million at the 5^{th} percentile. Furthermore, as discussed earlier, swap DV01, which measures risk, can be compared with bank equity, which measures capacity to absorb risk. Swap DV01 relative to equity is 0.038% for the aggregate banking system, and the mean and median values of this ratio are both less than 0.001% in magnitude.

We find that the interest rate risk of swaps varies across banks. Figure 1 shows the distribution of interest rate risk in terms of the ratio of net notional to asset (Panel A) and the ratio of DV01 to equity (Panel B). The large mass at zero in both panels reflects absence of any swap position in about one quarter of banks. The ratio DV01 to equity varies from -0.031% at the 5^{th} percentile to 0.025% at the 95^{th} percentile. That this distribution is close to symmetric indicates that losses from interest rate changes at one bank are offset by gains at another bank.

Another way to understand the magnitude of swap DV01 is in terms of balance sheet volatility, i.e., in terms of swap gains or losses, quantified using historical rate volatility, relative to bank assets. Along these lines, we assume a daily standard deviation of interest rates of 5 basis points, which is somewhat high for our sample period but representative of longer time periods. In that case, a one-standard deviation change in rates over a 63-trading day quarter is about $5 \times \sqrt{63}$, or 40 basis points. Combining this standard deviation with DV01 statistics gives balance sheet volatilities. More specifically, with a mean bank DV01 of $3 million, the quarterly standard deviation of changes to the value of swap positions due to changes in rates is 40 times $3 million, or $120 million. For the median bank, with a DV01 of $10,000, the quarterly standard deviation is only $400,000. These standard deviations of $120 million and $400,000 are economically small compared with mean and median bank assets of $62 billion and $9 billion, respectively.

[19] Net notional actually exaggerates the reduction of exposure, because, in the presence of counterparty risk, longs with one counterparty do not fully offset the risk of shorts with another counterparty. Baker et al. (2021) show, however, that exposure is dramatically reduced even when netting longs and shorts only within counterparty relationships. In their sample, $231 trillion of notional exposure reduces to $13.9 trillion in 5-year risk equivalents. As an aside, note that net notional also almost certainly exaggerates the reduction of operational risk, for which notional amount may actually be the best indicator: the likelihood of operational problems most likely increases with the number of line items, which is likely highly correlated with notional amount.

C. *Swap dealers vs. non-swap dealers*

Table 4 provides a breakdown of the summary statistics for swap dealers relative to non-swap dealers. Total bank assets of swap dealers are much larger than for non-swap dealers. Swap dealers account for $8.8 trillion in bank assets with an average of $798 billion per bank. Non-swap-dealers account for $4.7 trillion in banks assets and an average of $22 billion.

Swap dealers and non-swap dealers are comparable in terms of their funding mix and their asset holdings. They both primarily use core deposits, 70.9% for dealers versus 75.1% for non-dealers; non-core liabilities, 19.9% versus 14.4%; and equity, 11.4% versus 12.1%. Both dealers and non- dealers primarily hold loans, 53.1% versus 70.2%, but dealers hold fewer than non-dealers. Finally, dealers hold more securities than non-dealers, 21.9% versus 17.5%, and also hold more cash, 8.8% versus 4.3%.

The empirical evidence is consistent with a large portion of swap positions being generated by market-making businesses, which are characterized by large notional amounts and offsetting long and short positions. First, swap dealers account for the vast majority of swap notional amount, with $93.7 trillion versus $0.94 trillion for non-swap-dealers. Second, the vast majority of netting happens at the swap dealers: their notional amount of $93.7 trillion falls by a factor of more than 100 to a net notional of $628 billion. While netting reduces non-swap-dealer notional amount as well, the reduction is not nearly as large, falling from $937 billion to $155 billion.

Turning to our preferred measure of interest rate risk, DV01, we find that the aggregate DV01 of swap dealers is almost the same as that of the entire banking system at $568 million. Conversely, the DV01 of non-swap-dealers is close to zero at $17 million. Aggregate DV01 to equity is limited for both groups, however, at 0.06% for swap dealers and less than 0.003% for non-swap-dealers. In contrast, the interest rate risk of bank assets relative to equity is much larger.

Taken together, the summary statistics reveal a striking finding. Notional amounts– the most commonly-cited measure of banks' exposure to swaps– suggest that large banks are significantly exposed to swaps. Our results show, however, that the swap positions of most large banks have close to zero interest rate risk. Aggregate interest rate risk from swaps is quantitatively small and concentrated among a small number of swap dealers.

VI. Do banks use swaps for hedging?

A. Hedging bank assets

In this section we analyze the impact of interest rate swap exposure on bank returns. If banks use interest rate swaps for hedging, we expect that the change in the market value of the swap portfolio is offset by a corresponding change in the market value of the asset or liability that the derivative is hedging. For example, if a bank uses interest rate swaps to hedge the interest rate exposure of their long-term asset holdings, we expect that the bank return is unchanged if interest rates increase. In contrast, if banks use interest rate swaps for speculation, we expect to find that a change in the market value of a bank's swap portfolio has a significant effect on the bank's return. For example, if a bank is speculating on a decline in interest rates, then the bank should realize a positive return when interest rates decrease and a negative return if interest rate increase.

We empirically test whether banks use interest rate swaps for speculation or hedging using data on DV01s and bank stock returns. We measure the change in value of a bank i's swap portfolio, $SwapReturn_{i,t}$, from $t-1$ to t as follows:

$$SwapReturn_{it} = -\frac{SwapDV01_{it-1} \times \Delta y_t \times 10,000}{Equity_{it-1}}, \tag{1}$$

where $SwapDV01_{i,t-1}$ is the Swap DV01 at $t-1$, Δy_t is the five-year swap rate at time t minus the five-year swap rate at time $t-1$, and $Equity_{it-1}$ is the market equity of bank i at $t-1$.

$SwapReturn_{i,t}$ captures the change in a bank's market value coming *solely* from changes in the value of the bank's swap portfolio because of interest rate changes. Intuitively, the swap return depends on two factors. The first factor is the $SwapDV01$ divided by market equity, which measures the relative change in the bank value for a one basis point change in the swap rate. The second factor is the change in the swap rate measured in percentage points. Following standard convention, we multiply the yield change by $10,000$ to convert the yield change into basis points. Further note that we multiply this expression by -1. We do so because the standard market convention is that $SwapDV01_{it}$ is the change in the value of the swap portfolio for a one-basis-point *decline* in interest rates.

To illustrate this measure, consider a bank with a swap DV01 of \$1 million and a market equity of \$1 billion at the start of the quarter. Suppose the five-swap swap rate increases by 20 basis points over the quarter. Hence, $SwapReturn_{it} = -\frac{\$1 \times 0.2\% \times 10{,}000}{\$1{,}000} = -0.02$, i.e. the bank equity value would drop by 2% because of its swap exposure to the interest rate increase.

Panel A of Table 5 reports $SwapReturn_{it}$ for our sample of 145 publicly listed banks from Q4 2017 to Q4 2019. We find that the average quarterly swap return is economically small at -0.008% with a standard deviation of 0.985%. The 10^{th} and 90^{th} percentiles of the distribution are also economically small at -0.194% and 0.209%, respectively. For comparison, the average bank equity return is 0.508% and the standard deviation is 9.964%. This shows that the variation in swap return is economically small relative to the variation in bank equity returns.

We examine the relationship between the bank equity return and the return on the swap portfolio using the following OLS regression:

$$BankReturn_{it} = \alpha_t + \delta_i + \beta \times SwapReturn_{it} + \epsilon_{it} \quad (2)$$

where $BankReturn_{it}$ is bank i's equity return over the quarter t, $SwapReturn_{it}$ is bank i's return on the swap portfolio during quarter t, δ_i are bank fixed effects, and α_t are quarter fixed effects. Standard errors are double-clustered at the bank time level.

The coefficient of interest is β, which captures whether the return on the swap portfolio covaries with the bank's equity return. As a benchmark, we expect a coefficient of 0 if the bank uses interest rate swaps for hedging because swaps would hedge offsetting asset holdings, thereby leaving overall bank returns unaffected. In contrast, if banks use interest rate swaps for speculation we would expect a coefficient of 1. Specifically, a rise in interest rates would lead to a negative swap return, which would lower the bank equity return.[20]

Panel B of Table 5 presents the results. Column (1) reports the specification without bank and time fixed effects. We find a statistically insignificant coefficient of 0.059. We cannot reject the hypothesis that the coefficient is equal to 0 but we reject the hypothesis that it is equal to 1 at the 1% level. Columns (2) and (3) report the specifications that includes time fixed effects and time and bank fixed effects, respectively. The coefficients are statistically insignificant at -0.009 and -0.077, respectively. In both specifications, we again cannot reject a coefficient of 0 but reject a coefficient of 1 at the 1%-level. These results suggest that banks use swaps for hedging purposes.

Moreover, we find that the explanatory power of Swap DV01 for bank equity returns is low. Across the two specifications, the marginal R2 of including Swap DV01 is 0.001% or less. This indicates that swap returns have no statistical power in explaining variation in bank stock returns. This evidence is again inconsistent with banks using swap for speculation. Instead, it suggests that bank use swaps to hedge the interest rate exposure of interest-

[20]Note that speculation assumes that banks invest in interest rate swaps to generate interest rate exposure equivalent to investing in long-term, fixed-rate assets.

rate sensitive assets or liabilities, thereby reducing the explanatory power of changes in the swap value.

Figure 2 shows a graphical representation of this result. The figure provides a binscatter plot of the bank equity return (y-axis) and $\Delta SwapReturn_{i,t}$ (x-axis) for each quarter from 2017Q3 to 2019Q4. We winsorize both variables at the 5%-level to minimize the impact of outliers. The figures show that there is no consistent relationship between the two variables. The coefficient of regressing the equity return on $\Delta SwapReturn_{i,t}$ varies across quarters but this relationship is driven by a handful of outliers each quarter. The $R2$s are low varying between 0.1% and 3.7% across quarters.

B. Alternative usage of interest rate swaps

In this section, we examine alternative motivations to hold swap positions beyond hedging purposes. The first motivation is to serve as a dealer for interest rate swaps, i.e., engaging in the active trading of swaps to capitalize on bid-ask spreads. This involves earning profits from facilitating trades in swaps across a large number of counterparties and entails taking on both long and short positions without holding any significant exposure to interest rates. The second motivation revolves around meeting corporate demand for fixed-rate loans. Banks achieve this by combining floating-rate loans with interest rate swaps, effectively transforming them into fixed-rate loans. This approach enables banks to cater to the preferences of borrowers seeking stable interest rate payments, while issuing floating-rate loans that can be securitized more easily.

B.1. Swap-dealing business

Swap dealers are banks authorized by the Commodity Futures Trading Commission to operate as a swap dealers. Swap dealing activities are highly concentrated in the banking sector, with only 12 U.S. banks registered as swap dealers during our sample period. [21] As a consequence, we expect that swap dealers would generally exhibit larger notional amounts compared to non-swap dealers, even when adjusting for other bank characteristics. Nevertheless, we expect swap dealers to hedge their swap positions as part of their risk management strategy. This implies that the presence of swap positions should not create interest rate risk exposure for swap dealers relative to non-swap dealers.

[21] There were 12 registered swap dealers from 2010 to 2018, and 11 after 2018.

We analyze the impact of being a swap dealer using the following OLS regression:

$$Notional_{it} = \alpha_t + \beta \times Dealer_i + \gamma \times X_{it} + \epsilon_{it} \tag{3}$$

where $Notional_{it}$ is the total notional of swaps held of bank i at time t, $Dealer_i$ is an indicator variable equal to 1 if bank i is a swap dealer and zero otherwise, X_{it} are bank characteristics, and α_t are time fixed effects. We do not include bank fixed effects since they would be collinear with the indicator variable of being a swap dealer. We double cluster the standard errors at the bank level and quarter level.

Panel A of Table 6 presents the results. Column 1 finds that being a swap dealer leads to a substantial increase in the notional amount relative to assets, with a coefficient of 43. This indicates a significantly higher notional amount for swap dealers compared to non-swap dealers. Column 2 shows that, after controlling for asset size, the coefficient decreases to 23.2, remaining economically sizable and statistically significant. For context, the coefficient for bank size stands at 5.3, suggesting that being a swap dealer is equivalent to a fourfold increase in bank size. Subsequent Columns 3, 4, and 5 incorporate additional controls for various bank characteristics, such as the core deposit ratio, loan ratio, and securities for sale ratio. The coefficients on these variables are not statistically significant, while the impact of being a swap dealer on the notional amount remains consistent and unchanged. These results suggest that a considerable proportion of the notional amount is attributed to banks' swap-dealing business.

Panel B of Table 6 examines interest rate risk. We estimate equation (3) after replacing notional value with swap DV01 relative to bank equity. Column 1 finds that being a swap dealer leads to a slight increase in swap DV01 to equity, with a coefficient of 1.1%. However, in Column 2, after accounting for asset size, the coefficient drops to 0.4% and loses its statistical significance. Furthermore, in Columns 3, 4, and 5, we incorporate additional controls for the core deposit ratio, the loan ratio, and the securities for sale ratio. These controls have minimal impact on the results, and the coefficient associated with being a swap dealer remains largely unchanged. These findings imply that being a swap dealer does not have an economically significant effect on swap DV01 to equity.

The findings suggest that swap dealers maintain notably larger swap positions compared to non-swap dealers, all while effectively managing interest rate risk. These results imply that swap dealer's substantial notional exposures are largely attributed to their swap-dealing activities.

B.2. Hedging floating-rate loans

Banks extend loans to firms and other borrowers, and these loans often take the form of floating-rate loans. The bank's preference for floating-rate loans is driven, at least in part, by their ease of securitization when compared to fixed-rate loans. However, many borrowers have a preference for fixed-rate loans, prompting banks to offer a combination of a floating-rate loan with a long swap. In this way, the borrower's floating rate loan has been synthetically transformed into a fixed-rate loan, because it makes fixed payments on the swap while its floating rate payments on the loan are returned from receiving floating on the swap. Furthermore, the bank's long swap position accomplishes this transformation while accommodating the bank's preference for offering floating-rate loans. This raises the question whether banks use swaps to hedge the interest rate risk of this long swap position.

To answer this question, we analyze the proportion of derivative transactions conducted with customers, where customers are defined as all derivative counterparties other than swap dealers and clearinghouses. In practice, many customers are firms that sell swaps (i.e., pay fixed and receive floating) to convert floating-rate loans to fixed-rate obligations. We start by analyzing the impact of bank characteristics using the following OLS regression:

$$CustomerShare_{it} = \alpha_t + \beta \times Dealer_i + \gamma \times X_{it} + \epsilon_i \tag{4}$$

where $CustomerShare_{it}$ is the share of bank i's long swaps with customers at time t. The other variables are the same as in (3). We compute the customer share based alternately on the national value and the DV01 of long swaps. We restrict the analysis to banks with a non-zero notional value for long swaps (143 banks).

Panel A of Table 7 provides the results. Column 1 finds that swap dealers have a lower share of notional with customers with a coefficient of -0.33. However, the relationship flips once we control for bank size and the coefficient becomes positive at 0.15. The effect of bank size is negative and statistically significant. A doubling of bank size leads to a decline in the share of the notional amount by customers by 14 percentage points. Columns 3, 4, and 5 show that these results are similar when adding the same controls as in Table 6. Panel B of Table 7 finds similar results when using the share of DV01 with customers as the outcome variable. These results show that long swap positions with customers are largely a function of bank size and that smaller banks do more of it.

Next, we analyze whether banks hedge the interest rate risk associated with long swap positions sold to customers. We can gauge whether banks effectively mitigate this exposure using our detailed data. Specifically, we identify instances where a bank hedges a long swap by simultaneously initiating a short swap position on the same day through an identical, offsetting contract with a dealer. This practice is particularly relevant for non-swap dealer banks, as they lack a swap-dealing business, which would otherwise offer alternative methods for hedging long swaps.

To conduct our hedging analysis, we focus on all non-swap dealer banks. Given the significance of bank size, as highlighted earlier, we first examine non-swap dealers with assets less than $100 billion (116 banks). Our findings, as illustrated in Panel A of Table 8, indicate that these banks hold long swaps with an aggregate notional value of $167 billion. Out of these, an aggregate notional value of $113 billion of long swaps are with customers and the remaining $53 billion are with dealers. This means that 68% of long swaps are with customers. Among long swaps with customers, we identify $79.7 billion worth of long swaps hedged through back-to-back short swaps executed with dealers. This indicates that banks hedge 71% of their long swaps with customers using identical offsetting short swaps. Importantly, this quantity provides a lower bound for the overall hedging activity, as some banks adopt alternative methods to hedge interest rate risk, such as hedging their long swaps on a portfolio basis rather than hedging each long swap with an offsetting short swap. The portfolio approach is more efficient in terms of trading costs, but requires more sophisticated technology systems and more coordinated trading operations.

The outcomes for the average and median bank are similar, but with even more pronounced customer involvement and higher hedging rates. The average banks has a customer share of 86% and the median bank exclusively trades long swaps with customers, resulting in a customer share of 100%. Moreover, we are able to match 57% for the average banks and 73%, respectively, of the long swap positions to identical offsetting short swap positions executed on the same day with a dealer.[22]

These findings suggest that most banks primarily hold swap positions to provide services to their customers. Furthermore, a substantial portion of banks hedges interest rate risk by promptly offsetting the vast majority of their long swap exposure with back-to-back or perfectly offsetting short swaps. In other words, banks receive fixed in swaps as part of their lending business and hedge the resulting interest rate risk by paying fixed to dealers.

To provide a comparative analysis, we perform the same examination for non-swap dealers with assets exceeding $100 billion (11 banks). As shown in Panel B of Table 8, we find that these banks hold an aggregate notional value of $326 billion and about $87 billion are with customers. Notably, these banks have a large amount of long swaps with dealers, which can be attributed to their use of long swaps to hedge interest rate exposure for fixed-rate liabilities, particularly long-term fixed-rate debt. For long swaps with customers,

[22]We note that mean and median customer and hedging shares do not have to equal the appropriate ratios of the mean and median notional amounts.

we identify about $34 billion worth of back-to-back short swaps with dealers, serving as a hedge against long swaps sold to customers. This indicates that banks hedge out 39% of long swaps with identical short swaps. As before, it is essential to recognize that this value is a lower bound as banks have alternative hedging methods for these swaps. Anecdotally, the use of alternative methods is more prevalent among large banks.

Overall, our findings demonstrate that non-swap dealer banks actively hedge out a substantial portion of their interest rate exposure from long swaps with customers with perfectly offsetting short swaps with dealers. This aligns with non-swap dealer banks accommodating borrowers seeking to swap floating-rate loans into fixed-rate loans while simultaneously mitigating the interest rate risk of those accommodations.

VII. How important are swaps for banks' interest rate risk exposure?

In this section, we address the significance of swaps in banks' overall interest rate risk hedging. To accomplish this, we first assess banks' interest rate risk stemming from their assets and liabilities. We present our methodology for measuring this exposure and subsequently compare it to interest rate exposure from swaps. Furthermore, we explore how banks hedge their overall interest rate risk.

A. Measuring interest rate of bank asset and liabilities

We obtain data on bank assets and liabilities from U.S. Call Reports provided by Wharton Research Data Services. The data contain quarterly observations of the income statements and balance sheets of all U.S. commercial banks. The data also contain bank-level identifiers that we use to match the bank data to the CFTC data. We double-check the accuracy of the merge using information on bank names and location contained in both datasets. We construct bank asset, liability, and income variables following Drechsler, Savov and Schnabl (2021).

Call reports provide detailed information on loans, securities, deposits, and non-deposit liabilities. For securities, call reports provide maturity information on mortgage-backed securities (RMBS), other mortgage-backed securities (other MBS), and other non-MBS debt securities. For loans, call reports report provide maturity information for residential mortgage loans and other loans and leases. Additionally, call reports specify information on total deposits by type (checking, savings, small and large) and total non-deposit liabilities. For assets and liabilities other than deposits, call reports provide term buckets that specify the remaining maturity or the next repricing date. The level of detail for term buckets slightly varies across categories and is less comprehensive for the category of other MBS. For deposits, call reports include maturity information for term deposits.

We estimate the interest rate risk for each asset and liability, measured as DV01 and duration, as follows:

1. Non-MBS debt securities are mostly non-amortizing, fixed-rate assets, in which most of the present value is paid at maturity, For these assets maturity is a good indicator of interest rate risk. Therefore, we compute the interest rate risk assuming that it is equivalent to that of a par bond of corresponding maturity. For easy reference, we refer below to this methodology as the "par correspondence."

   Call reports provide information on remaining maturity (or, in the case of floating-rate assets, the time until the next interest rate reset) for the following buckets: less than 3 months, 3 months to 12 months, 1-3 years, 3-5 years, 5-15 years, and greater than 15 years. For all but the last bucket, we assume that the maturity (or time to reset) is equal to the center of the relevant term bucket. For the bucket of 15 years or greater we assume a maturity of 22.5, which is halfway between 15 years and the typically longest maturity of 30 years. We further assume the interest rate is equal to the swap rate of that maturity in that quarter.

   For example, say that, in a given quarter, when the 10-year swap rate was 2%, a bank had $100 million of non-MBS Securities in the term bucket of 5 to 15 years. In this case, the paper assumes that the bank's DV01 or duration in that bucket is that of a 10-year par bond at a yield of 2%. This approximation for interest rate risk works well if non-MBS debt securities are mostly non-amortizing (which they are).[23]

   We note that our data includes floating-rate instruments, in which periodic resets of interest rates to prevailing market rates cause these instruments to sell for nearly par on those reset dates, i.e., the time to the next repricing is the appropriate indicator of interest rate risk (e.g., floating-rate bond).[24] Given that securities are allocated to term buckets based on the reset dates for floating-rate instruments, our methodology ensures that loans with short-term resets have close to zero duration.

2. RMBS are amortizing, fixed-rate assets, in which much of the principal is paid be-

[23]We also make the reasonable assumptions that instruments in a bucket do not sell lopsidedly at significant premiums or significant discounts and that instruments in a term bucket have maturities or times to next repricing symmetrically around the center of the bucket.

[24]For example, a 30-year floating-rate bond that resets its interest rate every three months really has the interest rate risk of a three-month fixed-rate asset.

fore maturity and subject to the borrower's prepayment option. Both of these features shorten the effective duration of mortgage-backed securities, with the prepayment option doing so in a rate-contingent manner.

Call reports provide the same term buckets as for non-MBS securities. We again assume that the term of assets is equal to the center of the distribution. For RMBS with a remaining maturity of less than 1 year, the prepayment risk is less relevant and we compute duration and DV01 the same as we do for non-MBS securities using par correspondence.

To account for the prepayment option for RMBS with a remaining maturity of more than one year, we make use of industry risk models. We assign the duration corresponding to those of the nearest applicable indexes available on Bloomberg. For example, RMBS in the 5- to 15-year buckets are assigned a duration equal to that of U.S. MBS Fixed-Rate GNMA 15-year index in that quarter.

3. Other MBS are amortizing, fixed-rate assets, similar to RMBS. However, as mentioned above, we have less information on their term buckets because call reports only specify whether the expected average life is less or more than 3 years. We assume that the remaining maturity is either 1.5 years (half between 0 and 3) or 4.5 years (half between 0 and 5), respectively, and apply par correspondence using expected average life.

4. Residential mortgage loans are generally amortizing, fixed-rate assets, like RMBS. Call reports provide the same information on term buckets as for RMBS. We follow the same methodology to compute interest rate risk.

5. Other loans and leases are mostly non-amortizing, fixed-rate assets, similar to non-MBS securities. Call reports provide the same information on term buckets as for non-MBS securities. We therefore apply the par correspondence developed for non-MBS securities to compute interest rate risk.

6. Non-deposit liabilities are usually fixed-rate borrowings with the principal being paid at maturity. Call reports provide information on term buckets that is similar to non-MBS securities. We therefore apply the par correspondence developed for non-MBS securities to compute interest rate risk.

7. We handle the duration of deposits separately, as discussed below.

We note that our methodology for estimating a bank's interest rate risk does not include assets and liabilities for which the call reports do not provide detailed maturity data. The main omitted categories are federal funds and repurchase agreements; trading assets and liabilities; direct holdings of real estate; investments in subsidiaries; intangibles; equity; and items classified as "other."

However, we believe that our estimation still provides a sensible representation of a bank's interest rate risk for the following reason. Federal funds and repurchase agreements do have interest rate sensitivity, but typically very little, as their terms are typically very short, with the majority overnight. Omitting trading assets and liabilities are potentially more of a concern, although it turns out that they comprise a very small fraction of assets and liabilities in the sample.[25] The remaining categories of assets and liabilities not included in the estimation of interest rate sensitivity and not traditionally included in the analysis or hedging of interest rate risk.

To summarize, our methodology quantifies interest rate risk for a large fraction of bank balance sheets. On average, 86% of the assets are so quantified, with a standard deviation of 11%, and with only 13 banks (5 of which are very small) having ratios less than 70%. Coverage on the liability side is even greater, with an average of 96% of individual bank liabilities quantified, with a standard deviation of 6%, and with only 6 banks having ratios less than 70%.

B. *Overall interest rate risk*

Panel A of Table 9 presents the results on aggregate interest rate risk for the main sample (218 banks) from 2017Q1 to 2019Q4. Banks primarily hold cash, loans, and securities. Total cash holdings are $1.7 trillion with zero duration. Total loans are $7.4 trillion, with $1.46 trillion being residential mortgage loans and $5.99 trillion being other loans. The average loan duration is 2.21 years, with residential loans having a duration of 3.47 years and other loans having an average duration of 1.90 years. Total securities are $2.66 trillion, with $1.1 trillion in non-MBS securities, $1.11 trillion in RMBS, and $0.44 trillion in other MBS. The average security duration is 4.18 years. Non-MBS securities have a duration of 4.84 years, while RMBS and other MBS have an average duration of 4.02 and 2.92 years, respectively.

On the liabilities side, banks hold deposits and non-deposit liabilities, with total non-deposit liabilities amounting to $0.7 trillion and an average duration of 1.16 years. Given the short duration of non-deposit liabilities, it shows that long-term debt does not play an important role in funding most banks. Summing up, banks have total net holdings of $10.7 trillion with an average duration of 2.49 years.

Panel B of Table 9 presents the results for the average bank. The average bank has a loan

[25]Across the 250 banks as of June 2018, trading assets were, on average, about 0.4% of individual bank assets, with a standard deviation of less than 2%, and with just three banks having ratios of more than 10%. Trading liabilities are of even less importance, with an average ratio of trading to total liabilities of less than 0.2%, a standard deviation of about 0.6%, and with a maximum of just over 5%.

duration of 2.86 years and a securities duration of 4.32 years. These estimates are slightly above the corresponding estimates for the overall system, suggesting that larger banks hold slightly shorter duration assets. There is significant variation in exposure across banks, with a standard deviation of loan and securities duration of 1.37 and 1.75 years, respectively. In total, the average bank has a duration of 2.98 years.

To compare the interest rate risk of bank assets to exposure from swaps, it helps to express the exposure in terms of DV01. The average bank has a DV01 of $7.5 million in loans, $5.5 in securities, and $2.1 in non-deposit liabilities. Total average bank-level DV01 is $12.2 million. Panel C of Table 9 reports the corresponding value for interest rate swaps. The average bank has a notional swap value of $434 billion with a DV01 of $2.68 million. Hence, even though notional swap exposure is much larger than bank assets, the DV01 of banks and liabilities is about 5 times larger than the DV01 of interest rate swaps.

C. Hedging interest rate risk with deposits

Our results indicate that the average banks does not use swaps to hedge the interest rate risk of their assets and liabilities. While the notional amounts of swaps is large, they are not an economically significant hedge. But if banks do not use swaps to hedge the interest rate exposure of their assets, how might they be hedged?

Deposits are an alternative way to hedge interest rate risk. While conventional wisdom suggests that deposits have zero or very short duration, Drechsler, Savov and Schnabl (2021) show that this view is incorrect. They show that banks actively invest in building and maintaining deposit relationships, and that this has two related implications. First, a bank's deposit beta– the increase of a bank's funding cost from an increase in the short-term interest rate– is less than one. Second, a bank's deposit franchise has duration, which falls as beta increases. As a result, because deposits are bank liabilities, deposit duration contributes negative duration to a bank's overall interest rate exposure and can hedge the interest rate risk of bank assets. To investigate this view of hedging at banks, we test whether the deposit durations of banks in our sample that would be consistent with hedging interest rate risk do indeed fall as deposit betas increase. This extends the work of Drechsler, Savov and Schnabl (2021) as we include the interest rate exposure of swaps in our measurement of interest rate risk.

We begin by defining the implied deposit DV01 or duration of a bank as the DV01 or duration of deposits that completely hedges the overall interest rate exposure of a bank, or, in other words, that sets the sum of exposures of all assets and liabilities, including deposits, to zero. We then compute the implied deposit duration for each bank using the DV01 of assets, liabilities, and swaps, as calculated above. We find that the banking industry's total DV01 across assets and non-deposit liabilities is \$2.67 billion and the total swap DV01 is \$0.585 billion. Therefore, assuming that the aggregate sector is fully hedged with a zero DV01, the implied DV01 of deposits is negative \$3.26 billion, and the implied duration of these deposits is \$3.26 billion × 10,000 / 10.7 trillion, or 3.05 years.

We compute the implied deposit duration for each bank separately. We find an average implied deposit duration of 2.74 years with a standard deviation of 1.17 years. Panel A of Figure 3 plots a histogram of the implied deposit duration winsorized at 1% and 99% level. We find significant variation ranging from close to 0 to slightly above 6 years with the mass of the distribution at around 3 years.

We measure a bank's deposit beta following Drechsler, Savov and Schnabl (2021). Our dataset covers the period from Q32017 to Q42019. We therefore use the deposit beta estimated for the 2015-2019 interest rate cycle following Drechsler et al. (2023). Specifically, the deposit beta is the change in the bank-level interest expense rate at the start of the hiking cycle (Q2 2015) to the end of the hiking cycle (Q2 2019) scaled by the change in Fed funds rate over the same period. As mentioned earlier, the deposit beta captures the increase in a bank's funding cost as function of the short-term interest rate. For example, a deposit beta of 0.3 means that a bank's interest expenses increase by 30 bps for each 100 bps increase in the Fed funds rate.

Panel B of Figure 3 plots a histogram of the deposit beta. The average deposit beta is 0.27 with a standard deviation of 0.12. We find significant variation in betas ranging from close to 0 to 0.6.

Next, we examine whether, as predicted by Drechsler et al. (2023), implied deposit duration falls with deposit beta. We start with the our main bank sample and drop 5 banks that do not have a deposit beta because they were not operating in the second quarter of 2015. This leaves a sample of 213 banks over 10 quarters. We estimate the following OLS regression:

$$Duration_{it} = \alpha_t + \gamma \times \beta_i^{Deposit} + \delta X_{it} + \epsilon_{it}, \tag{5}$$

where $Duration_{it}$ is the implied deposit duration of bank i at time t, $\beta_i^{Deposit}$ is the bank i's deposit beta, and X_{it} are control variables. We cluster the standard errors at the bank-level to account for the fact that the deposit beta only varies at the bank level.[26]

Figure 4 provides a binscatter plot of the relationship between the implied deposit duration and the deposit beta for the cross-section of banks at the end of our sample period. We find a strong negative relationship: a higher implied deposit duration is associated with a

[26]The results are similar if estimated as single cross-section either at the start or the end of our sample period.

lower deposit beta. The relationship is economically significant in that a 0.1 increase in the deposit beta is associated with a 0.3 decrease in deposit duration. The relationship appears to be linear in the deposit beta. This finding indicates that banks use deposits to hedge their interest rate exposure.

Table 10 presents the results from the OLS regression specificied in equation (5). Column (1) reports the results without using control variables. We find a statistically significant of coefficient of -3.01, which means that 0.1 increase in the deposit beta lowers the implied deposit duration by around 0.3 years. We note that the constant is 3.52. This suggests that a hypothetical bank with a (particularly high) deposit beta of 1 has an implied deposit duration of less than 1 year, similar to a money market fund, and would be close to hedged. In other words, banks without a deposit franchise should have a very short asset duration, a conclusion consistent with banks using deposits to hedge most of their interest rate risk.

Column (2) finds that the coefficient of interest remains similar at -3.01 after adding quarter fixed effects. Columns (3) and (4) show that the coefficient is similar at -3.4 and -3.5 after adding controls for the share of funding coming from transaction deposits, savings deposits, small time deposits, foreign deposits, and equity. The coefficient on the control variables are statistically insignificant. This suggests that the deposit beta is a sufficient statistic for a bank's exposure to interest rate risk.[27]

In summary, we find that banks use deposits, rather than swaps, to economically hedge their overall interest rate exposure from bank assets, liabilities, and swaps.

VIII. Conclusion

This paper asks whether banks use interest rate swaps to hedge the interest rate risk of their long-term assets. We use transaction-level data to estimate the interest rate risk of the swap positions of the 250 largest U.S. banks. We find that the average bank has a large notional amount of swaps of $434 billion. But after accounting for offsetting swap positions, the average bank has essentially no exposure to interest rate risk: a 100-basis-point increase in rates increases the value of its swaps by 0.1% of equity. There is variation across banks, with some bank swap positions decreasing and some increasing with rates, but aggregating swap positions at the level of the banking system reveals that most swap exposures are offsetting. Therefore, as a description of prevailing practice, we conclude that swap positions are not economically significant in hedging the interest rate risk of bank

[27] Note that we do not include asset side controls since we would be overcontrolling for variation in duration on the asset side.

assets.

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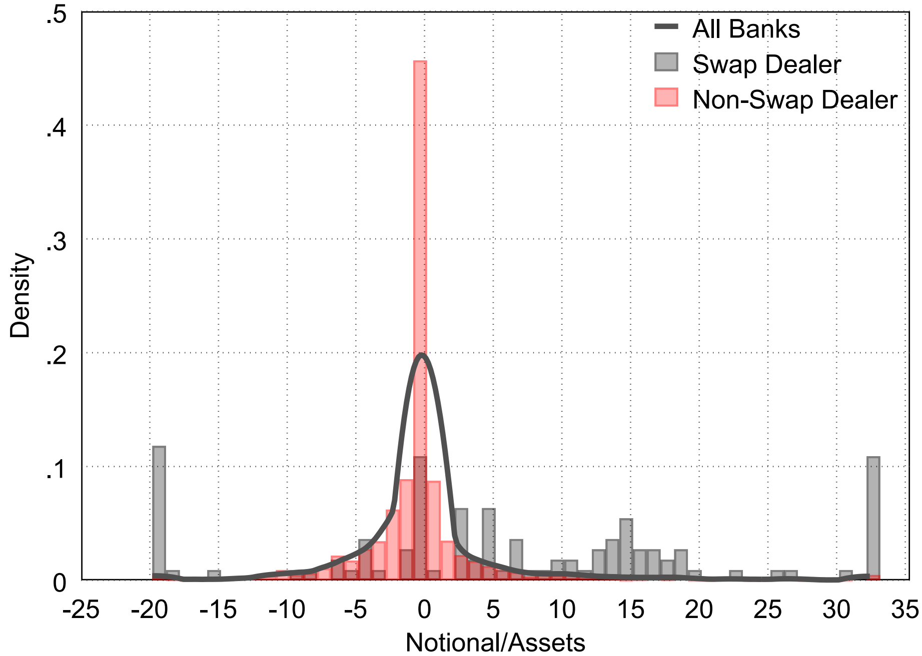
Panel A.
Distribution of the Ratio of Net Notional to Assets



Panel B.
Distribution of the Ratio of Swap DV01 to Equity

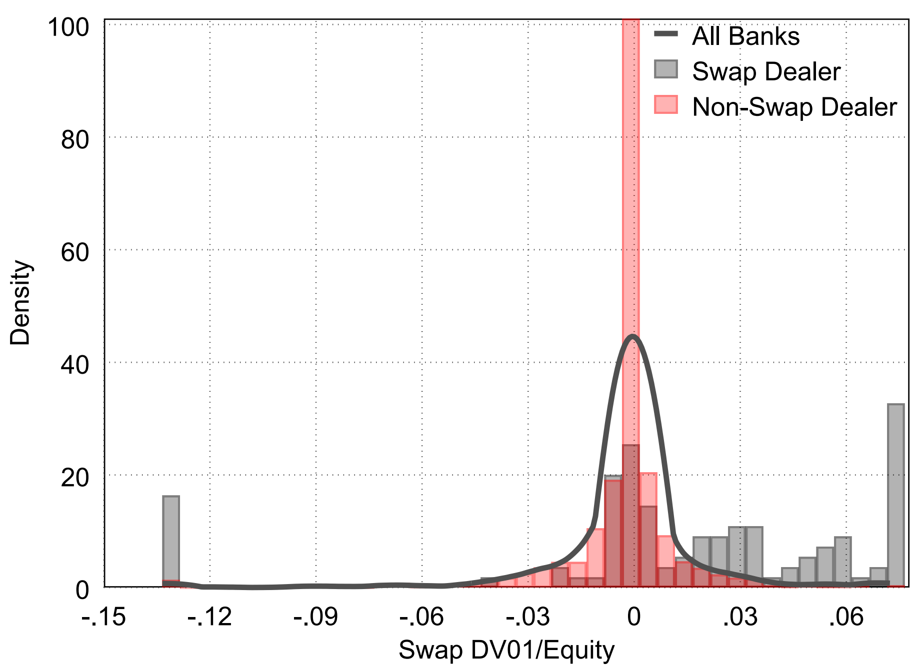


Figure 1. **Net notional/assets and swap DV01/equity**. The figure plots the distributions of the ratio of net notional to assets in percent (Panel A) and the ratio of swap DV01 to equity in percent (Panel B). The data are quarterly from the third quarter of 2017 to the fourth quarter of 2019. A black kernel density estimate line approximates the aggregate banking sector, while red and gray bins represent non-swap and swap dealers, respectively.

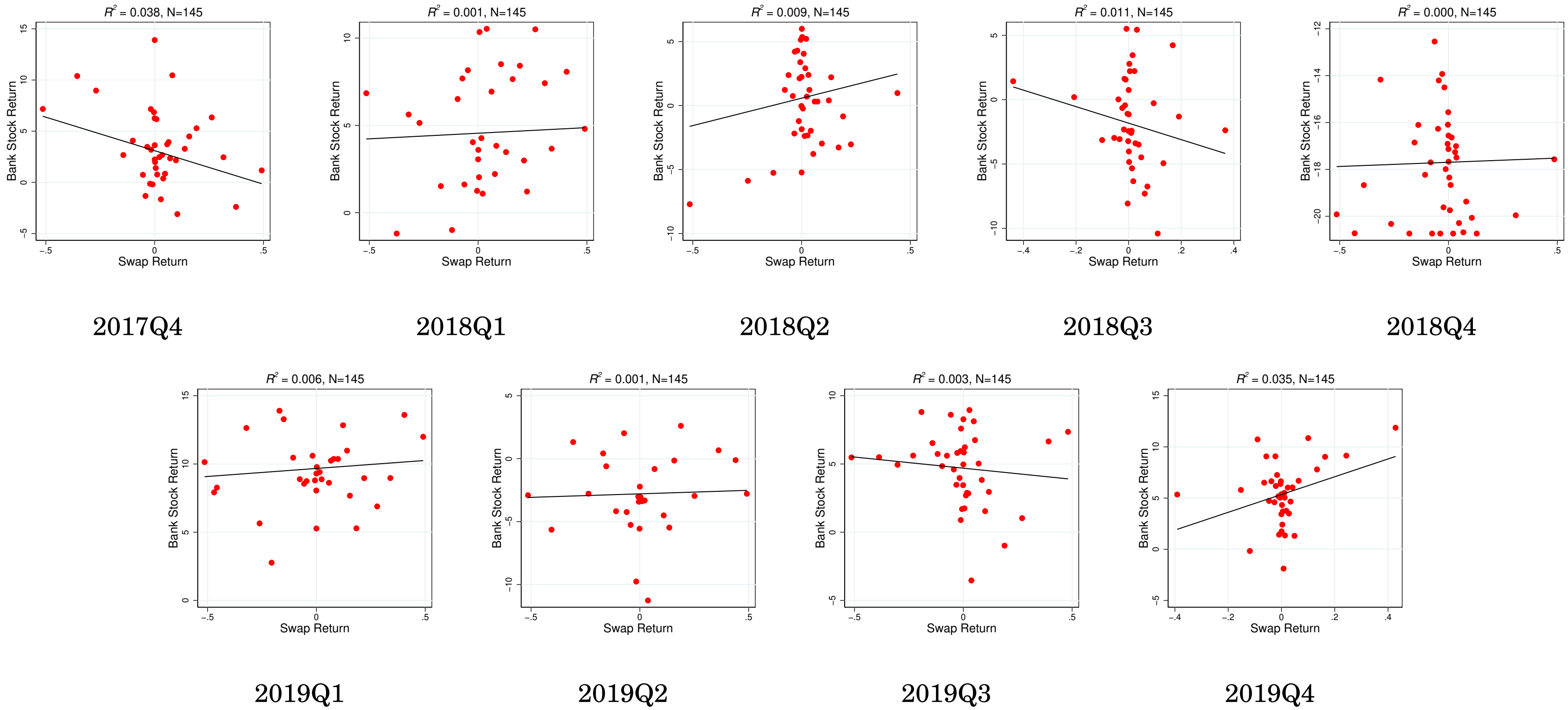
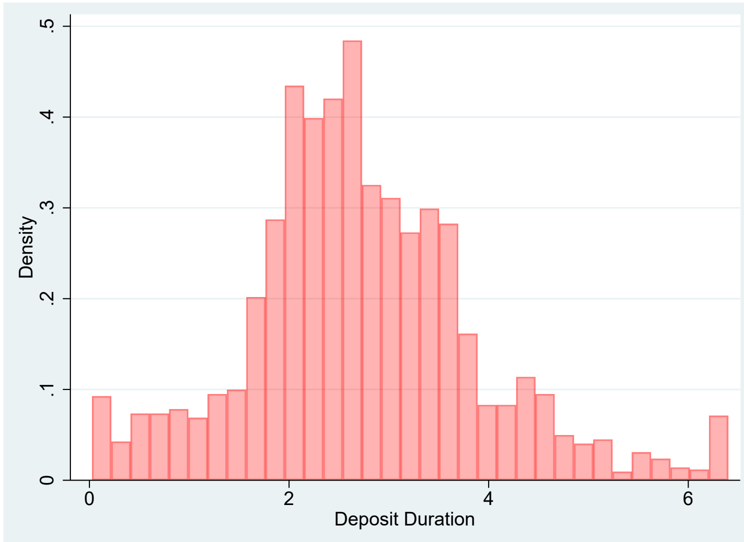
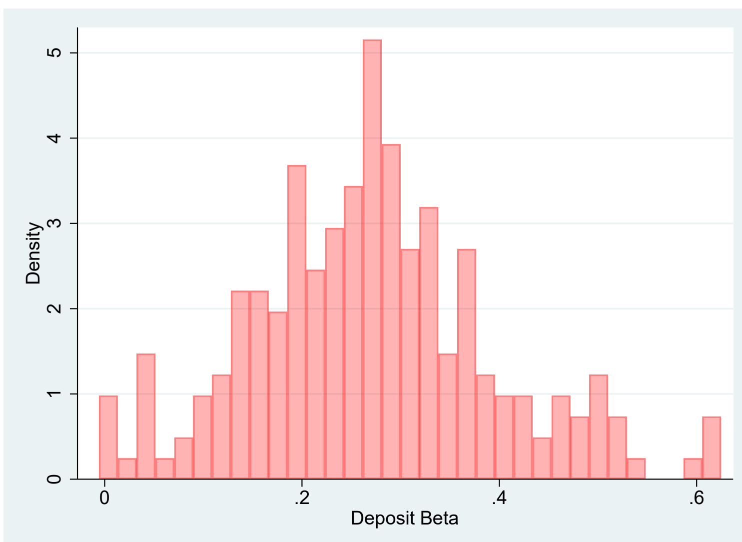


Figure 2. **Swap returns and bank returns by quarter**. This figure shows the correlation between bank stock return and swap return by quarter. in each figure, the dependent variable is the bank stock return over the quarter and the independent variable is the swap return (defined in equation (1)), which measures the relative change in the value of the swap portfolio solely coming from interest rate changes over the quarter. Both variables are winsorized at the 5% level by quarter. Quarter end dates align with the reporting dates of the derivative exposure data in calculating stock returns and changes in Treasury rate. They are 9/29/2017, 12/15/2017, 3/16/2018, 6/15/2018, 9/14/2018, 12/14/2018, 3/15/2019, 6/14/2019, 9/13/2019, and 12/13/2019.



Panel A. Histogram of the implied deposit duration



Panel B. Histogram of the deposit beta

Figure 3. **Implied deposit duration and deposit beta**. Panel A shows the distribution of implied deposit duration across banks. The sample is the full sample of banks with a deposit beta from 2017Q3 to 2019Q4 (213 banks). The implied deposit duration is the required duration of deposits such the bank total DV01 from assets, liabilities, and swaps is fully hedged, i.e., the bank-level DV01 is equal to zero. Panel B shows the distribution of the bank deposit beta estimated during the 2015-2019 interest rate cycle. The deposit beta captures the change in the bank interest rate expenses relative to a change in the Fed funds rate. Both the implied deposit duration and the deposit beta are winsorized at the 1% level.

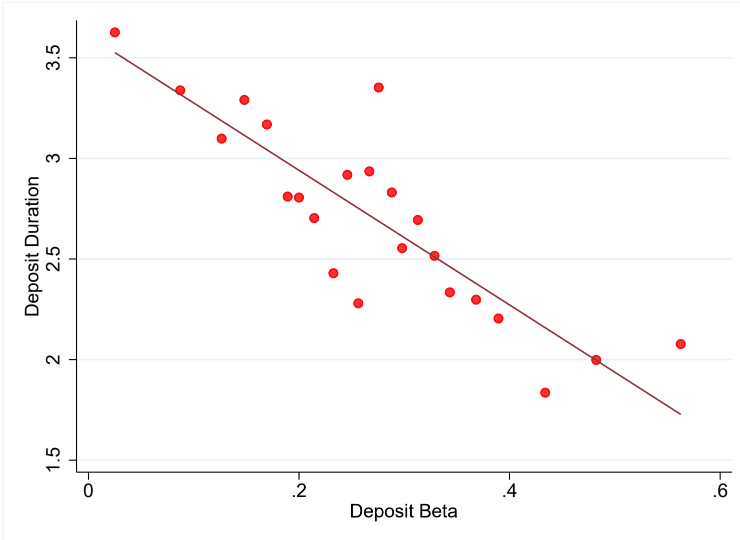


Figure 4. **Hedging bank assets, liabilities and swaps with deposits**. This figures provides a binscatter plot of the implied deposit duration versus the deposit beta. The sample is the cross-section of banks in 2019Q4. The implied deposit duration is the required duration of deposits such the bank total DV01 from assets, liabilities, and swaps is fully hedged, i.e., the bank-level DV01 is equal to zero. The deposit beta captures the change in the bank interest rate expenses relative to a change in the Fed funds rate. Both the implied deposit duration and the deposit beta are winsorized at the 1% level.

Table 1

Growth in Interest Rate Derivatives

The data are from the publicly available Call Reports. Prior to 1995, interest rate derivatives included swaps only. A bank is engaged in these derivatives if it has a non-zero notional amount of interest rate derivative positions.

Panel A: All Banks

Year	No. of Banks	Engaged in Derivatives	Notional (bn. $)	Ratio of Notional to Assets	Ratio of Notional to Equity	Type
1985	14,261	2%	186	0.1	1.1	Swaps only
1990	12,195	4%	1,717	0.5	7.9	Swaps only
1995	9,852	2%	10,023	2.3	29.0	All
2000	8,234	2%	32,084	5.3	61.9	All
2005	7,442	10%	84,390	9.6	95.5	All
2010	6,466	16%	193,359	16.3	147.9	All
2015	5,300	22%	138,301	9.4	84.1	All
2020	4,342	27%	115,911	5.7	56.2	All
2022	4,060	23%	139,620	6.4	67.5	All

Panel B: 250 Largest Banks

Year	No. of Banks	Engaged in Derivatives	Notional (bn. $)	Ratio of Notional to Assets	Ratio of Notional to Equity	Type
1985	250	53%	185	0.1	2.1	Swaps only
1990	250	71%	1,703	0.8	13.8	Swaps only
1995	250	50%	10,014	3.3	43.4	All
2000	250	40%	32,081	6.5	79.2	All
2005	250	70%	84,374	11.5	114.4	All
2010	250	76%	193,333	18.7	167.4	All
2015	250	87%	138,271	10.6	94.0	All
2020	250	92%	115,796	6.3	62.6	All
2022	250	90%	139,563	7.1	74.3	All

Panel C: Swap Dealers

Year	No. of Banks	Engaged in Derivatives	Notional (bn. $)	Ratio of Notional to Assets	Ratio of Notional to Equity	Type
2010	12	100%	191,400	28.9	276.3	All
2015	12	100%	136,742	16.9	155.0	All
2020	11	100%	113,231	10.6	110.1	All
2022	11	100%	136,567	11.9	128.9	All

Table 2

Interest Rate Derivative Positions at Banks

The data are collected from publicly available bank call reports as of the fourth quarter of 2022. Swap dealers are banks that are registered as dealers with the Commodity Futures Trading Commission. Panel A reports interest rate derivative positions for the 20 largest banks. Panel B reports interest rate derivative positions by bank size and dealer status.

Panel A: Interest Rate Derivative Positions at 20 Largest Banks

Bank Rank	Bank Name	Swap Dealer	Notional (bn. $)	Assets (bn. $)	Ratio of Notional to Assets	Ratio of Notional to Equity
1	J.P. Morgan Chase Bank	Yes	33,585	3,202	10.5	110.6
2	Bank of America	Yes	13,091	2,419	5.4	58.1
3	Citibank	Yes	31,902	1,767	18.1	194.1
4	Wells Fargo Bank	Yes	1,303	1,718	6.0	63.8
5	U.S. Bank	Yes	779	585	1.3	17.7
6	PNC Bank	Yes	537	552	1.0	12.2
7	Truist Bank	No	256	546	0.5	4.3
8	Goldman Sachs Bank	Yes	45,896	487	94.2	950.2
9	Capital One	No	167	453	0.4	3.4
10	TD Bank	No	359	387	0.9	8.4
11	Bank of NY Mellon	No	263	325	0.8	9.8
12	State Street B&TC	No	42	298	0.1	1.6
13	Citizens Bank	No	220	226	1.0	9.3
14	First Republic Bank	No	0	213	0.0	0.0
15	Morgan Stanley Private Bank	Yes	47	210	0.2	2.9
16	Silicon Valley Bank	No	5	209	0.0	0.3
17	Fifth Third Bank	Yes	129	206	0.6	6.6
18	Morgan Stanley Bank	Yes	56	201	0.3	2.8
19	M&T Bank	No	65	200	0.3	2.7
20	Keybank	Yes	118	188	0.6	9.1

Panel B: Interest Rate Derivative Positions by Bank Size and Dealer Status

Bank Group	No. of Banks	Engaged in Derivatives	Notional (bn. $)	Ratio of Notional to Assets	Ratio of Notional to Equity
All Banks	4,060	23%	139,620	6.4	67.5
250 Largest Banks	250	90%	139,620	7.1	74.3
Swap Dealers	11	100%	136,567	11.9	128.9

Table 3

Summary Statistics

The sample includes quarterly observations for the 218 largest banks from the third quarter of 2017 to the fourth quarter of 2019. Aggregate amounts are computed by first summing across banks in each quarter and then averaging across quarters. Derivative exposure variables are scaled by assets or equity. Bank characteristics ratios are scaled by assets or liabilities. Equity is book equity. The derivatives exposure variables are winsorized at the 5% level.

	All Banks					
	Aggregate (1)	Mean (2)	St. Dev. (3)	Median (4)	p5 (5)	p95 (6)
Derivatives Exposure (in bn. $)						
Notional	94,680	434	(3,016)	0.4	0.000	85.6
Net Notional	784	3.6	(72.9)	0.0	−1.3	9.9
Market Value	50	0.232	(2.199)	0.0	−0.043	0.156
Swap DV01	0.585	0.003	(0.044)	0.000	−0.001	0.003
Derivatives Exposure						
Uses Interest Rate Derivatives		74.0%	(44.0%)	100%	0%	100%
Ratio: Notional to Assets	704%	10.80%	(15.70%)	3.91%	0.00%	60.03%
Ratio: Net Notional to Assets	5.9%	−0.031%	(3.766%)	0.000%	−7.432%	10.395%
Ratio: Market Value to Assets	0.375%	0.030%	(0.095%)	0.001%	−0.122%	0.312%
Ratio: Swap DV01 to Equity	0.038%	−0.001%	(0.012%)	0.000%	−0.031%	0.025%
Derivatives Characteristics						
Share of DV01 with Customers	47.2%	82.1%	(31.9%)	100%	0%	100%
Share of Swaps with Customers	46.9%	80.4%	(32.9%)	100%	0%	100%
Bank Characteristics						
Swap Dealer		0.050	(0.219)	0.000	0.000	1.000
Assets (bn. $)	13,505	62	(247)	9	3	169
Equity (bn. $)	1,521	7.08	(26.0)	1.1	0.4	22.2
Ratio: Cash to Assets	0.097	0.045	(0.035)	0.032	0.012	0.140
Ratio: Loans to Assets	0.548	0.693	(0.101)	0.714	0.450	0.829
Ratio: Securities to Assets	0.197	0.177	(0.088)	0.162	0.046	0.388
Ratio: Core Deposits to Liabilities	0.661	0.749	(0.062)	0.750	0.629	0.856
Ratio: Non-Core Liabilities to Liabilities	0.255	0.147	(0.069)	0.139	0.044	0.290
Ratio: Trade Liabilities to Liabilities	0.016	0.001	(0.001)	0.000	0.000	0.005
Ratio: Equity to Liabilities	0.113	0.121	(0.024)	0.118	0.083	0.174
Observations		2,180				

Table 4

Summary Statistics: Breakdown by dealer status

The sample includes quarterly observations for the 218 largest banks from the third quarter of 2017 to the fourth quarter of 2019. Aggregate amounts are computed by first summing across banks in each quarter and then averaging across quarters. Derivative exposure variables are scaled by assets or equity. Bank characteristics ratios are scaled by assets or liabilities. Equity is book equity. The derivatives exposure variables are winsorized at the 5% level.

	Swap Dealers			Non-Swap Dealers		
	Aggregate (1)	Mean (2)	St. Dev. (3)	Aggregate (4)	Mean (5)	St. Dev. (6)
Derivatives Exposure (in bn. $)						
Notional	93,742	8,522	(10,598)	937	5	(18)
Net Notional	628	57	(320)	155	1	(6)
Market Value	48.7	4.4	(8.8)	1.9	0.0	(0.1)
Swap DV01	0.568	0.052	(0.191)	0.017	0.000	(0.001)
Derivatives Exposure						
Uses Interest Rate Derivatives		96.4%	(18.8%)		72.8%	(44.5%)
Ratio: Notional to Assets	1,069%	51.6%	(18.2%)	19.6%	8.6%	(12.2%)
Ratio: Net Notional to Assets	7.3%	3.734%	(6.843%)	3.2%	−0.231%	(3.417%)
Ratio: Market Value to Assets	0.556%	0.595%	(1.435%)	0.036%	0.025%	(0.146%)
Ratio: Swap DV01 to Equity	0.061%	0.010%	(0.019%)	0.003%	−0.002%	(0.011%)
Derivatives Characteristics						
Share of DV01 with Customers	47.3%	50.8%	40.3%	55.1%	84.9%	29.5%
Share of Swaps with Customers	47.2%	49.7%	40.9%	36.0%	83.1%	30.6%
Bank Characteristics						
Swap Dealer	1.000	1.000	(0.000)	0.000	0.000	(0.000)
Assets (bn. $)	8,784	798	(778)	4,721	22	(42)
Equity (bn. $)	934	85	(80)	587	3	(5)
Ratio: Cash to Assets	0.117	0.088	(0.042)	0.060	0.043	(0.033)
Ratio: Loans to Assets	0.484	0.531	(0.084)	0.666	0.702	(0.094)
Ratio: Securities to Assets	0.203	0.219	(0.079)	0.187	0.175	(0.088)
Ratio: Core Deposits to Liabilities	0.616	0.709	(0.068)	0.745	0.751	(0.061)
Ratio: Non-Core Liabilities to Liabilities	0.311	0.199	(0.076)	0.150	0.144	(0.068)
Ratio: Trade Liabilities to Liabilities	0.025	0.004	(0.002)	0.001	0.001	(0.001)
Ratio: Equity to Liabilities	0.106	0.114	(0.015)	0.124	0.121	(0.025)
Observations		110			2,070	

Table 5

Swap DV01 and Bank Returns

Bank stock return is from quarter t to $t+1$. The independent variable is the swap return, which measures the change in the value of the swap portfolio relative to bank market solely due to interest rate changes from t to $t+1$ (as defined in equation (1)). Quarter end dates align with the reporting dates of the derivative exposure data in calculating stock returns and changes in Treasury rate. They are 9/29/2017, 12/15/2017, 3/16/2018, 6/15/2018, 9/14/2018, 12/14/2018, 3/15/2019, 6/14/2019, 9/13/2019, and 12/13/2019. Standard errors are clustered at the bank level.

Panel A: Summary Statistics	
Mean of Bank Stock Return	0.508%
… SD	9.964%
Swap DV01 (bn. $)	0.004
Mean of Mkt. Eq. (bn. $)	13.874
Mean of Δ (bps)	−5.57
Swap return	
… Mean	−0.008%
… Standard deviation	0.985%
… 10th Percentile	−0.194%
… 90th Percentile	0.209%
Obs.	1,305

Panel B: Bank Return and Swap Return

	Bank Stock Return		
	(1)	(2)	(3)
Swap return	0.059	−0.009	−0.077
	(0.084)	(0.080)	(0.071)
Time FE	No	Yes	Yes
Bank FE	No	No	Yes
Obs.	1,305	1,305	1,305
R^2	0.0000	0.680	0.704
Within R^2	0.0000	0.0000	0.0002

Table 6

Swap DV01 and Bank Characteristics

The sample includes quarterly observations for the 218 largest commercial banks in the U.S. from 2017Q3 to 2019Q4. The securities for sale ratio excludes Treasuries. Standard errors are clustered at the bank level.

Panel A: Notional/Assets and Bank Characteristics

	Notional/Assets				
	(1)	(2)	(3)	(4)	(5)
Swap Dealer	43.010***	23.207***	22.675***	23.433***	23.147***
	(5.369)	(6.871)	(6.925)	(6.771)	(6.725)
Log Assets		5.322***	5.211***	5.307***	5.186***
		(0.983)	(0.972)	(0.991)	(1.004)
Core Deposits Ratio			−11.662	−11.056	−10.792
			(10.281)	(10.256)	(10.275)
Loan Ratio				5.581	2.320
				(6.796)	(8.617)
Sec. for Sale Ratio (excl. Treas)					−7.309
					(11.277)
Time FE	Yes	Yes	Yes	Yes	Yes
Obs.	2,180	2,180	2,180	2,180	2,180
No. of clusters	218	218	218	218	218
R^2	0.372	0.500	0.504	0.505	0.506

Panel B: Swap DV01 and Bank Characteristics

	Swap DV01/Equity				
	(1)	(2)	(3)	(4)	(5)
Swap Dealer	0.011**	0.004	0.004	0.005	0.005
	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
Log Assets		0.002***	0.002***	0.002***	0.002***
		(0.001)	(0.001)	(0.001)	(0.001)
Core Deposits Ratio			0.005	0.006	0.007
			(0.009)	(0.009)	(0.009)
Loan Ratio				0.011	0.002
				(0.008)	(0.010)
Sec. for Sale Ratio (excl. Treas)					−0.020
					(0.012)
Time FE	Yes	Yes	Yes	Yes	Yes
Obs.	2,180	2,180	2,180	2,180	2,180
No. of clusters	218	218	218	218	218
R^2	0.054	0.088	0.089	0.098	0.110

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Table 7

Share of Swaps with Customers and Bank Characteristics

The sample includes quarterly observations for the 218 largest commercial banks in the U.S. with a non-zero long swap value from 2017Q3 to 2019Q4 (143 banks). The securities for sale ratio excludes Treasuries. Standard errors are clustered at the bank level.

Panel A: Share of Notional Amount with Customers

	Share of Notional Amount with Customers				
	(1)	(2)	(3)	(4)	(5)
Swap Dealer	−0.329***	0.154*	0.177*	0.217**	0.240**
	(0.046)	(0.092)	(0.102)	(0.098)	(0.095)
Log Assets		−0.140***	−0.138***	−0.126***	−0.112***
		(0.017)	(0.016)	(0.018)	(0.017)
Core Deposits Ratio			0.338	0.329	0.255
			(0.353)	(0.360)	(0.328)
Loan Ratio				0.436	0.765***
				(0.269)	(0.238)
Sec. for Sale Ratio (excl. Treas)					0.835***
					(0.284)
Constant		1.210***	0.951***	0.618*	0.293
		(0.040)	(0.268)	(0.333)	(0.323)
Time FE	Yes	Yes	Yes	Yes	Yes
Obs.	1,294	1,294	1,294	1,294	1,294
No. of banks	143	143	143	143	143
Within R^2	0.079	0.305	0.311	0.327	0.354

Panel B: Share of DV01 with Customers

	Share of DV01 with Customers				
	(1)	(2)	(3)	(4)	(5)
Swap Dealer	−0.336***	0.079	0.102	0.151	0.177*
	(0.048)	(0.092)	(0.102)	(0.096)	(0.092)
Log Assets		−0.121***	−0.118***	−0.105***	−0.090***
		(0.017)	(0.017)	(0.019)	(0.018)
Core Deposits Ratio			0.349	0.342	0.265
			(0.358)	(0.364)	(0.331)
Loan Ratio				0.510*	0.868***
				(0.275)	(0.231)
Sec. for Sale Ratio (excl. Treas)					0.918***
					(0.284)
Constant	0.849***	1.178***	0.910***	0.519	0.161
	(0.024)	(0.042)	(0.271)	(0.339)	(0.316)
Time FE	Yes	Yes	Yes	Yes	Yes
Obs.	1,290	1,290	1,290	1,290	1,290
No. of banks	143	143	143	143	143
Within R^2	0.087	0.267	0.273	0.298	0.331

Table 8

Hedging floating-rate loans

The sample includes quarterly observations for the main sample (218 restricted non-swap dealers with non-zero exposure to long swaps (127 banks). Panel A presents results for banks with less than $100 bn in assets (116 banks). Panel B presents results for banks with more than $100 bn in assets (11 banks).

	Panel A: Assets < $100bn				
	Long Swap Notional	Long Swap with Customers	Back-to-back Hedge	Customer Share	Hedging Share
Aggregate ($ bn)	166.8	113.29	79.7	68%	70%
Mean ($ mil)	1,438	977	687	86%	57%
Stand Dev	(3,005)	(1,756)	(1,228)	(28%)	(37%)
Median	385.3	304.60	194.6	100%	73%

	Panel B: Assets >= $100bn				
	Long Swap Notional	Long Swap with Customers	Back-to-back Hedge	Customer Share	Hedging Share
Aggregate ($ bn)	325.9	87.90	34.5	27%	39%
Mean ($ mil)	29,627	7,991	3,135	25%	26%
Stand Dev	(27,899)	(8,394)	(4,275)	(21%)	(27%)
Median	23,750	6,723	194.6	27%	20%

Table 9

Interest Rate Risk of Bank Assets, Liabilities, and Swaps

The sample estimates the interest rate exposure for bank assets, liabilities, and swaps. The sample are the 218 largest commercial banks in the U.S. from 2017Q3 to 2019Q4. Holdings are denoted in $ billion and denote either assets or liabilities. We measure interest rate exposure as both duration ad DV01 (in $ million. The main text discusses the estimation of these variables. Panel A provides summary statistics by asset and liability type for the aggregate banking sector. Panel B provides summary statistics for the average bank by asset and liability type. Panel C provides comparable summary statistics for swap exposure.

	Panel A: Aggregate Banking Sector		
	Holdings ($ bn)	Duration (yr)	DV01 ($ mil)
Cash	1,772.0	0.00	0.0
Loans	7,443.6	2.21	1,641.1
– Residential Mortgage Loans	1,457.6	3.47	504.0
– Other Loans	5,986.1	1.90	1.137.2
Securities	2,662.6	4.18	1,107.9
– Residential MBS	1,119.9	4.02	445.8
– Other MBS	437.2	2.92	127.5
– Non-MBS	1,105.6	4.84	534.7
Non-deposit liabilities	713.4	1.16	82.8
Total	10,700.5	2.49	2,666.2
	Panel B: Average Bank		
	Holdings ($ bn)	Duration (yr)	DV01 ($ mil)
Cash	8.1	0.00	0.0
	(49.7)	(0.00)	(0.0)
Loans	34.1	2.86	7.5
	(117.5)	(1.37)	(24.1)
– Residential Mortgage Loans	6.7	2.98	2.3
	(28.6)	(0.81)	(10.6)
– Other loans	27.5	2.87	5.2
	(90.5)	(1.68)	(14.0)
Securities	12.2	4.32	5.1
	(49.9)	(1.75)	(21.5)
– Residential MBS	5.1	3.51	2.1
	(27.6)	(0.81)	(11.8)
– Non-MBS	5.1	5.86	2.5
	(24.4)	(3.08)	(10.9)
– Other MBS	2.0	2.82	0.6
	(4.8)	(0.83)	(1.5)
Non-deposit liabilities	3.3	1.43	2.1
	(15.5)	(1.03)	(3.4)
Total	49.1	2.98	12.2
	(181.8)	(1.23)	(43.6)
	Panel C: Average Bank Swap Exposure		
	Notional ($ bn)		DV01 ($ mil)
Interest Rate Swaps	434.7		2.68
	(3,016)		(44.1)

Table 10

Implied Deposit Duration

The table examines whether banks use deposit to hedge their interest rate exposure to asset, liabilities, and swamps. The sample is the full sample of banks with a deposit beta from 2017Q3 to 2019Q4 (213 banks). The implied deposit duration is the required duration of deposits such the bank total DV01 from assets, liabilities, and swaps is fully hedged. The deposit beta captures the change in the bank interest rate expenses relative to a change in the Fed funds rate. The control variables are the share of liablities financed with equty, transaction deposits, saving deposits, small time deposits, and foreign deposits, respectively. The standard errors are clusted at the bank-level.

	Implied deposit duration			
	(1)	(2)	(3)	(4)
Deposit beta	−3.009***	−3.009***	−3.440***	−3.449***
	(0.624)	(0.625)	(0.568)	(0.570)
Equity Share			−2.065	-1.952
			(3.143)	(3.171)
Transaction Deposit Share			−3.582	-3.591
			(1.800)	(1.808)
Saving Deposits Share			−2.066	-2.062
			(1.779)	(1.787)
Small Time Share			−2.996	-2.950
			(2.170)	(2.181)
Foreign Deposits Share			−4.162	-4.131
			(3.041)	(2.561)
Constant	3.516***	3.516***	5.709***	5.691***
	(0.172)	(0.172)	(1.644)	(1.652)
Quarter Fixed Effects	No	Yes	No	Yes
Observations	2,130	2,130	2,130	2,130
R^2	0.012	0.013	0.016	0.016